Education Department Bulletin

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New York State Museum

John M. Clarke, Director

Museum bulletin 128

GEOLOGY OF THE GENEVA-OVID QUADRANGLES

BY

D. DANA LUTHER

ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

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New York State Education Department
Science Division, November 20, 1908

Hon. Andrew S. Draper LL.D.
Commissioner of Education

SIR: I have the honor to communicate herewith for publication as a bulletin of the State Museum, a report on the geology of the Geneva and Ovid quadrangles, accompanied by a map on the scale of one mile to the inch.

Very respectfully yours
JOHN M. CLARKE
Director

State of New York
Education Department
COMMISSIONER'S ROOM

Approved for publication this 21st day of November 1908

Commissioner of Education

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GEOLOGY OF THE GENEVA-OVID QUADRANGLES

BY

D. DANA LUTHER

The geologic map of the Geneva and Ovid quadrangles covers an area of 455 square miles in the heart of the Finger Lakes region of central New York.

A part of this area embracing about 100 square miles lying to the north of Seneca lake and Seneca river is a low, flat, alluvial region diversified with many kames and drumlins, conical or oblong hills of sand and gravel that rarely reach a hight of more than 100 feet and are usually much lower.

In this region the soft red Vernon and gray Camillus shales that succeed the Medina sandstones and Lockport dolomites at the north were excavated during the glacial epoch to considerably greater depth than those harder rocks, thereby producing a broad shallow depression that extends eastward from Ontario county to Onondaga county, and through which the waters from a large part of the Finger Lakes drainage area reach Lake Ontario by way of the Seneca and Oswego rivers. The northern part of the Geneva quadrangle lies in this depression and although possessing features of extraordinary interest to the student of glacial geology is wholly devoid of rock outcrops by which the contact lines of the geologic subdivisions can be located. The area lying south of the Seneca river, however, presents entirely different characteristics as it lies on the sloping northern edge of the great New York plateau against which the ice sheet here spent a large part of its erosive force in deepening and enlarging the old preglacial depressions, now the Seneca lake and Cayuga lake valleys, to their present depth and size, leaving a broad separating ridge between them.

This ridge, barely above the present lake level at the north end, rises toward the south at an average rate of 50 feet per mile to 1400 feet above it at the south side of the Ovid quadrangle.

The higher eastern and western slopes are moderately steep, ranging from 100 to 250 feet per mile, while the lower reach 400 to 500 feet per mile and nearly vertical cliffs extend for many miles along the lake shores, in which there is a magnificent display of the stratigraphy of the region; the numerous ravines and gorges cut through the thin drift mantle that overspreads the ridge, some of which show rock walls 100 to 200 feet in hight, afford abundant opportunities for the collection of fossils. These conditions have made this region a specially attractive one to geologists and its stratigraphy and surface phenomena have been discussed by several scientific writers among whom are Prof. James Hall in the annual and final reports of the fourth geological district 1837 to 1842, and Dr D. F. Lincoln in a report on the geology of Seneca county published in the 14th Report of the State Geologist of New York, 1895.

STRATIGRAPHY

The following formations are represented on the map:

Devonic....	Chautauquan	Chemung sandstone
		Prattsburg shale
	Senecan.....	High Point sandstone
		West Hill flags and shale
		Grimes sandstone
		Hatch shale and flags
		Rhinestreet shale
		Cashaqua shale
		West River shale
		Genundewa limestone horizon
		Genesee shale
		Tully limestone
	Erian.......	Moscow shale
		Tichenor limestone
		Ludlowville shale
		Skaneateles shale
		Cardiff shale
		Marcellus shale
	Ulsterian....	Onondaga limestone
	Oriskanian..	Oriskany sandstone

Ontaric or Siluric....	Cayugan....	Manlius limestone
		Rondout waterlime
		Cobleskill waterlime
		Bertie waterlime
		Camillus shale

The strata composing the surface rocks of these quadrangles as delineated on the map have an aggregate thickness of 2140 feet of which 1460 feet are exposed by the gradual elevation of the land from 400 feet A. T. in the northeast corner of the Geneva quadrangle to 1860 feet A. T. near the southeast corner of the Ovid quadrangle and 680 feet are brought up by the elevation of the strata toward the north and east at an average rate of 24 feet per mile.

It is proper to call attention to the fact that variations in the thickness of the strata and the undulatory condition of the bedding make calculations of the dip of little value except as between any two specified points.

SILURIC

Camillus shale

The lowest and most northern of the rock series exposed on the Geneva quadrangle is the Camillus shale, a small outcrop showing 8 feet of the platten dolomites of the lower part of this formation occurring on Black creek 1 mile south of Tyre.

This is the only rock exposure on these quadrangles north of the Auburn branch of the New York Central Railroad, all of that region having a mantle of drift varying from a few feet in the lower swampy plains to 100 feet or more in the numerous drumlins and kames that diversify the landscape. Therefore the coloring is to be taken as showing the surface area of the rock formations in a plane having a presumed elevation of about 400 feet A. T.

The Camillus shale is that subdivision of the Salina group that succeeds the Vernon red shale and is composed in the lower part of thin dolomitic limestones and thin layers of soft shale and at the top has a bed of gypseous shale 35 feet thick, some parts of which are of sufficient purety to have, when pulverized, some economic value as land plaster and wall plaster. Gypsum was quarried about 1840 near Black brook west of Nichols Corners and the bed has been penetrated in the bottom of wells in that vicinity. It is not exposed along that stream now, the exposure south of Tyre being below it. It is well displayed, however, in the cliff along the north side of the Seneca river for a mile east of Seneca Falls, and in several places on the south side in cliffs and old quarries. More than 5000 tons were quarried annually in this immediate vicinity in the middle of the last century.

This stratum is exposed in a line of quarries and natural outcrops extending from Madison county to Genesee county showing a variable proportion of gypsum in the clay shales at different localities.

The first discovery of gypsum in the United States is said to have been made in the year 1792 at Camillus, N. Y. where the bed is extensively exposed; hence the formation name.

Traces of organic life are absent from the Camillus shale except for the rare appearance of the little ostracod, Leperditia alta (Conrad), and obscure markings that are perhaps trails made by this or a similar organism.

Bertie waterlime

This is a mass of impure magnesian limestone, hard and dark when freshly broken, but softening and changing to a light ashen gray or buff color when exposed.

It is usually in layers 3 inches to 10 inches in thickness, separated by thin partings of carbonaceous matter. Some of the layers are quite compact and in these the rock has a conchoidal fracture; others are thinly laminated and weather into a hard slaty shale.

The "cement rock" so extensively quarried in Erie county is in the upper part of this formation and some of the layers have been burned and used as waterlime all along its line of outcrops in the central and western part of the State. In this vicinity it has fallen into disuse for that purpose, probably because it has been found lacking in the proportion of silicon necessary to good cement.

The Bertie waterlime is well exposed in the rock wall on the south side of the river at Seneca Falls below the bridge and the contact with the Camillus shale at the base may be seen in the banks for half a mile eastward. As the upper contact is covered, the thickness can only be estimated, but it is approximately 22 feet. Fossils are rare in these beds but the few that do occur are exceedingly interesting as the fauna is a peculiar association of crustaceans, the remains of which while few and fragmentary in this vicinity, are more common at Buffalo and in Herkimer county and have made this horizon one of the most interesting of the New York series.

At Buffalo there have been collected from the Bertie limestone, the ostracod Leperditia scalaris Jones, Ceratiocaris accuminata Hall and an extensive eurypterid fauna. A few lingulas, Orbiculoidea and other brachiopods occur in the lower layers at Union Springs.

Cobleskill waterlime

In this locality this formation is composed of three or four layers of hard, dark limestone that after long exposure weathers to a dark brown.

It is exposed on the Geneva quadrangle only in the old McQuan quarry a mile southwest of Seneca Falls, where the upper layer, a compact coralline stratum 7 feet thick, and 1 foot of similar rock below without coral, yet remains uncovered.

The lower part not being exposed the actual thickness of the formation here is not known but on Frontenac island at Union Springs it is 8 feet, 6 inches thick and as it increases slowly toward the west 10 to 12 feet is a fair estimate of its thickness in this quarry.

In the western part of the State where the Cobleskill is known to quarrymen as "bullhead" it is lighter colored, scraggy and contains many small cavaties produced by the weathering out of small fossils and crystals of calcite.

It is everywhere quite fossiliferous. The heavy layer in the McQuan quarry is largely composed of the coral, Stromatopora concentrica Hall and on Frontenac island where the exposure is specially favorable for collecting and where fossils are more than commonly abundant, 30 species have been found to occur. Of these, the more common forms next to the Stromatopora are:

Favosites niagarensis? *Hall*
Halysites catenulatus *Linné*
Cyathophyllum hydraulicum *Simpson*
Spirifer crispus *var.* corallinensis *Grabau*
Stropheodonta varistriata *Conrad*
Whitfieldella sulcata (*Vanuxem*)
Ilionia sinuata *Hall*
Trochoceras gebhardi *Hall*
Leperditia alta (*Conrad*)

Rondout waterlime

Overlying the Stromatopora layer in the McQuan quarry there is a bed of dark somewhat shaly magnesian limestone 9 feet thick, some parts of which are dolomitic. It is the only exposure on this quadrangle of the Rondout waterlime, a formation 40 feet thick in the eastern part of the State, that by decrease in the amount of sediment or by transition in character, thins out in a westerly direction and is not known beyond Livingston county.

Fossils are rare in this formation here; Leperditia alta (Conrad) and L. scalaris Jones occur throughout the bed and segments of Eurypterus have been found 2 or 3 feet below the top of the bed.

Manlius limestone

This formation is prominent in the stratigraphy of Onondaga and Cayuga counties, but thins out rapidly in a westerly direction and does not reach the McQuan quarry which affords the only exposure of its horizon on this quadrangle. Flagstones and building blocks reported to be from an old quarry in the south part of Seneca Falls, are Manlius limestone, from which it is evident that it extends to the vicinity of that village.

When freshly quarried the rock is very dark and hard, but when weathered shows a straticulate structure and fades to a dull bluish gray color.

It contains many fossils of which the more common are Spirifer vanuxemi Hall, Stropheodonta varistriata Conrad and Leperditia alta (Conrad).

DEVONIC

Oriskany sandstone

The Helderbergian series of limestones that in eastern New York constitute the basal formations of the Devonic system all thin out in a westerly direction and disappear before reaching Cayuga county and in western central New York the Siluric waterlimestones are succeeded in some localities by thin lentils of coarse quartzitic Oriskany sandstone, cross-sections of ancient sandbars.

Where the sandstone is absent, as in the McQuan quarry which affords the only exposure of the Oriskany horizon on these quadrangles, the Rondout waterlime is separated from the Onondaga limestone by a thin layer of black carbonaceous matter 3 to 6 inches thick containing pebbles of waterlime and grains of black sand, but no fossils.

In Yawger's woods 2 miles northeast of Union Springs and 8 miles southeast of the McQuan quarry the Oriskany sandstone is 4 feet 6 inches thick and crowded with characteristic fossils mostly large brachiopods (Hipparionyx proximus, Spirifer arenosus, S. murchisoni, Chonostrophia complanata, Rensselaeri ovides, etc.). A thin stratum of this sandstone is exposed in the bed of Flint creek at Phelps, and at Buffalo the loose sands of Oriskany time sifted into fissures in the Cobleskill limestone, producing small sand " dikes."

Onondaga limestone

This appellation was first used by James Hall in the third annual report of the Fourth Geological District for 1838, page 309, and applied to " the gray crinoidal or Onondaga limestone which follows the Oriskany sandstone and is well characterized and distinguished from any other by its peculiar gray or grayish blue color and compact crystalline structure. Sometimes layers of chert or hornstone are interspersed between those of the limestone; and some of those contain much of that mineral while in others it occurs only in small nodules. When the lower layers abound in chert they contain few or no fossils while those containing little of it are full of them."

The upper beds are described on page 310 as the " Seneca limestone" which " succeeds the Onondaga and in some instances alternates with it. It is recognized by its darker blue color, fine texture and homogeneous structure. Like the Onondaga it contains much chert or hornstone."

Vanuxem, in the report on the third district for that year, page 274, describes the lower beds as the " gray sparry crinoidal limestone " and says, " This limestone is but a thin mass of from 8 to 12 feet in thickness " and on page 275 he speaks of the upper beds as " Seneca limestone. This rests upon layers of cornitiferous."

In 1824 Prof. Amos Eaton in *A Geological and Agricultural Survey of the District Adjoining the Erie Canal* introduced the name *Cornitiferous limerock* for a formation which evidently includes both the Onondaga and the Seneca limestones. He repeated his definition with the addition of other localities in his *Geological Nomenclature for North America,* 1828, page 25, and in the first edition of his *Geological Text Book,* 1830, page 42. He changed the name to *Corniferous limestone* in the *American Journal of Science* for 1839.

In the Final Report on the Fourth Geological District, 1843 Professor Hall redescribes the Onondaga as " included in the Corniferous limerock by Professor Eaton " and applies the term " Corniferous limestone " as equivalent to the " upper part of the Corniferous limerock of Eaton, Seneca limestone of the annual reports."

In volume 3, *Palaeontology of New York,* 1859, pages 42–45, the Onondaga and Corniferous limestones, together with the Schoharie grit and the Cauda-galli grit which do not extend as far west as these quadrangles are classified as composing the "Upper Helderberg group" and this term has been widely used, specially in connection with the fauna of those beds.

Investigations subsequent to the geological survey of 1837–42 have led to the conclusion that there are no well defined structural changes in the character of the limestones in this formation that are continuous for more than a short distance, the exceedingly irregular distribution of the chert making its presence or absence of no value as a guide to their stratigraphy, and the clearer subcrystalline character of the basal layers at some localities being due to aggregations of corals, crinoid stems and other fossils in a manner suggestive of coral reefs, in which the species are mainly if not entirely those found to occur in greater or less abundance in the higher beds.

In the reports of the fourth and third districts for 1838 in which the name Onondaga was first applied to the limestone as a unit term Hall and Vanuxem also used this word as a group term to designate the "Saliferous group of Onondaga," changing in the report for the succeeding year to "Onondaga salt group," thus duplicating the use of the word.

In 1899 Clarke and Schuchert in a revised *Classification of the New York Geologic Formations* eliminated "Onondaga" as a group term and continued it as a unit term in compliance with the rules of geologic nomenclature, its application being expanded to cover all of the limestone strata between the Oriskany sandstone horizon and Marcellus shale, which for reasons above stated are considered as constituting one formation. The name Seneca thus discontinued as a unit term, has been employed as the designation of a period or group (Senecan) for the formations extending from the top of the Hamilton to the top of the Portage beds.

The formation consists of a heavy deposit of limestone, very dark when freshly quarried but on exposure weathering to a light bluish gray color. Its line of outcrop from the Hudson river valley to Buffalo is marked by hundreds of quarries that have produced and are still producing enormous quantities of handsome and durable building stone, and valuable fluxing road material. Until recently the manufacture of quicklime from these beds was also an important branch of business.

It is 75 to 80 feet thick on this quadrangle and is composed of a series of even layers 6 inches to 3 feet in thickness separated by thin partings of shale or chert, these layers being usually divided by vertical joints into large rectangular blocks. At the base a few layers having usually a total thickness of 5 to 8 feet are composed largely of corals and are specially desirable for house trimmings.

Chert or hornstone, varying in color from black to light blue is unevenly distributed through a considerable part of the higher beds, occurring in nodular layers or rows of separate nodules, on the surface of the strata or compactly imbedded within them. Fragments of these cherty beds are scattered over the country south of the line of outcrop to which the protruding flinty nodes give a peculiarly scraggy appearance.

While the layers that contain a considerable proportion of chert are less valuable for building purposes, they afford in unlimited quantities the best quality of road metal found in western New York.

The area over which the Onondaga limestone is the surface rock in the Geneva quadrangle is divided by the Seneca river about equally, that part on the north side being mainly in a low flat region in which the rock is entirely covered by drift or alluvium.

A small outcrop of shaly limestone 2 miles north of Geneva and west of the Auburn branch of the New York Central Railroad is the only exposure of the Onondaga limestone on this quadrangle north of the river and lake. In the region adjacent to the river on the south side there is an average northward slope of 50 to 60 feet per mile on the surface and the drift mantle being but a few feet thick the rock appears in the fields and along the streams in many places.

The best exposures are afforded by the extensive quarries of which there are 10 or more in an irregular row beginning on the river bank a mile west of Waterloo and extending toward the southeast to the vicinity of Canoga. The basal layer is exposed slightly in McQuan's quarry and the cherty strata next above it at the Waterloo dam.

In the old quarry near the Lehigh Valley Railroad a mile west of South Waterloo, 25 feet of the beds just above the middle of the formation may be seen and the same horizon is now exploited in the Thomas Brothers quarry half a mile south of Waterloo; also in the Rorison quarry 2½ miles farther toward the southeast, and in others nearer Canoga. That these quarries are in the same horizon is shown by the appearance in each of a seam of soft grayish shaly marlyte 6 to 8 inches thick easily distinguished from other shaly partings in these beds. It overlies a nodular layer of chert 3 to 5 inches thick, but the rock for 10 to 12 feet above and below it is quite free from chert and in even tiers of convenient thickness, and therefore specially desirable for building purposes.

The upper layers appear along the bed of the stream that crosses the Waterloo-Romulus road 1½ miles southeast of Waterloo and in an old quarry by the roadside ¾ miles northeast of Kuneytown.

The fauna of the Onondaga limestone is a large one, the lists of the species given in New York State Museum bulletin 63 for the Canandaigua and Naples quadrangles containing 3 fishes, 39 crustaceans, 13 cephalopods, 3 pteropods, 38 gastropods, 15 lamellibranchs, 48 brachiopods, 4 crinoids and 30 corals, total 193.

Marcellus shale

This formation was described by both Hall and Vanuxem as admitting of division into two parts. The former says on page 177 of the Report on the Fourth Geological District, 1843: "The lower is very black, slaty and bituminous and contains iron pyrites in great profusion; some portions are calcareous and it is always marked by one or more courses of concretions or septaria which are often very large. This division terminates upward by a thin band of limestone above which the shale is more fissile and gradually passes from black to an olive or dark slate color." The limestone here referred to is now known as the Stafford limestone; it is 8 to 10 feet thick in Erie county, but thins out toward the east and is not known beyond Flint creek in Ontario county where it is but 4 inches thick. Its place in Seneca and Cayuga counties is shown by a thin band of lighter colored shales containing many of the fossils common in the limestone.

The term Marcellus shale is now restricted to the beds between the Onondaga limestone and the horizon of the Stafford limestone, and the beds formerly known as upper Marcellus are now designated Cardiff shale.

In Onondaga county and farther east the transition from the Onondaga limestone to the black Marcellus shale is abrupt, and clearly defined, but in the succeeding 15 feet of rock there are interstratified several thin layers of dark limestone and at the top of these basal beds there occurs the 2 foot stratum known to geologists as the Agoniatite limestone which extends to the western part of the State and is readily distinguished by its peculiar character and fossils.

The shales intervening between the Onondaga limestone and Agoniatite limestone become more calcareous westward from Marcellus and at Union Springs are mostly dark impure bituminous limestone, more or less shaly. On this quadrangle and in Ontario and Livingston counties they are still more calcareous and lighter colored and in the western part of the state are so far assimilated to the Onondaga limestone as to be not separable from that formation.

Above the Agoniatite limestone a row of large spherical concretions and a few thin calcareous flags are the only variations in the bed of densely black shale up to the horizon of the Stafford limestone. The Marcellus black shale has a thickness of 45 feet on the Geneva quadrangle. It is exposed along the bed of a small stream that crosses the Romulus road 2 miles south of Waterloo; in the bed of Kendig creek and on the east shore of Seneca lake south of the outlet; also, slightly in the road a mile west of Canoga spring.

The following is a list of the more common fossils of the Marcellus black shale:

Orthoceras subulatum *Hall*
Styliolina fissurella (*Hall*)
Pleurotomaria rugulata *Hall*
Nuculites oblongatus *Conrad*
Chonetes lepidus *Hall*
C. mucronatus *Hall*
Strophalosia truncata *Hall*
Liorhynchus limitare (*Vanuxem*)
L. multicosta *Hall*

Cardiff shale

In the absence of the Stafford limestone on this quadrangle, the Cardiff shale here succeeds directly the Marcellus shale as above described and is equivalent to the "Upper shale of Marcellus" of Vanuxem for which the name here used was substituted in New York State Museum bulletin 63, 1904, from its abundant exposure in the vicinity of Cardiff, Onondaga co.

As compared with the shale below the Stafford limestone the Cardiff shale is more argillaceous and fissile and gradually passes from black to an olive or dark slate color.

At the base of the formation a band of calcareous shale 2 feet thick in the horizon of the Stafford limestone is lighter colored and more fossiliferous than the succeeding beds, which are mostly dark and bituminous. In the upper part there are thin lentils of limestones composed usually of shells of the brachiopod, Liorhynchus limitare.

The densely black color and highly bituminous character of the Marcellus and Cardiff shales in central and western New York led to their frequent exploitation in pioneer days, in the mistaken belief that they were the surface outcrops of beds of coal. In recent years, as one result of their penetration in hundreds of deep borings they are known to searchers for natural gas as the "gas-bearing rocks."

Fossils are abundant in the lower Cardiff shales which contain many species found in the Stafford limestone that separates the Cardiff from the Marcellus shale in Ontario county and westward to Lake Erie. The more common of these are:

Phacops rana *Green*
Cryphaeus boothi *Green*
Homalonotus dekayi *Green*
Orthoceras subulatum *Hall*
Styliolina fissurella *Hall*
Pleurotomaria rugulata *Hall*
P. itys *Hall*
P. capillaria *Conrad*
P. sulcomarginata *Conrad*
Camarotoechia sappho *Hall*
Spirifer audaculus *Conrad*
S. fimbriatus *Conrad*

The upper shales are much less fossiliferous than the lower but the following forms are fairly common:

Strophalosia truncata *Hall*
Productella spinulicosta *Hall*
Chonetes mucronatus *Hall*
C. scitulus *Hall*
Liorhynchus limitare *Vanuxem*
Orbiculoidea minuta *Hall*
Pterochaenia fragilis *Hall*
Tornoceras discoideum *Conrad*

The Cardiff shales are exposed along the Lehigh Valley Railroad on the east side of Seneca lake near the foot, along Kendig creek at and above the forks and along the stream on the east side of the Romulus road 2 miles south of Waterloo. Other small outcrops occur in the southeastern part of the town of Fayette.

Skaneateles shale

This name was first applied to the beds that succeed the Cardiff shale at the foot of Skaneateles lake by Vanuxem in the Report of the Third District for 1839, page 380. In the final report, 1843, it is included in the "Hamilton group" which he says "includes all of the masses between the upper shales of Marcellus and the Tully limestone."

Hall, in the Report on the Fourth District, page 177, says "there is little advantage in separating the upper division of this (Marcellus) shale from the Hamilton group. The line of separation is nowhere well marked, the change in lithological character being gradual, while some of the fossils continue from one to the other."

On page 187 of that report, in describing the Hamilton group he says: "Along the banks of these lakes (Seneca and Cayuga) I have been able to trace the following subdivisions which hold good over considerable areas but which can not be relied on in every instance.

1 Dark, slaty fossiliferous shale, which rests directly upon the Marcellus. . . not very abundant in fossils.

2 Compact calcareous blue shale often passing into an impure limestone, thin and worthy of notice only from being somewhat persistent and marking the point of separation between two or more important shaly masses.

3 An olive, or often bluish fissile shale, resting upon the last named mass.

4 Ludlowville shale.

5 Encrinal limestone.

6 Moscow shale."

The first three of these subdivisions differ so slightly in both lithologic and faunal characteristics that they have been pretty much lost sight of as such, the loose term "lower Hamilton" having been commonly used for all the beds between the Cardiff and Ludlowville shales.

The Skaneateles shale, as the term is used in this bulletin, comprises 1, 2 and 3 of the above specified subdivisions. Its estimated thickness here is 200 feet, but owing to the general flatness of the region over which it is the surface rock there are no favorable exposures. The upper layers outcrop along a small stream 1 mile south of Fayette and the basal layers ¾ mile north of that village. The contact with the succeeding Ludlowville shale may be seen in the cliffs at the falls in the lower part of Big Hollow creek 3 miles north of Hayt Corners; in the ravine 1½ miles farther north at top of falls; along Reeder creek, a mile south of Varick station; and on the shore of Seneca lake north of Dey landing. The upper beds are also well displayed on the west side of Seneca lake in the ravine of Wilson's creek at and below the falls.

Fossils are less common in the Skaneateles shale than in the higher subdivisions of the Hamilton group, but the collector may expect to find good specimens of the following forms:

Phacops rana *Green*
Styliolina fissurella (*Hall*)
Pleurotomaria rugulata *Hall*
Lunulicardium curtum *Hall*
Nuculites oblongatus *Conrad*
Chonetes setiger *Hall*
Spirifer mucronatus (*Conrad*)
Ambocoelia umbonata *Conrad*
Liorhynchus limitare (*Vanuxem*)
L. multicosta *Hall*

Ludlowville shale

The transition from the Skaneateles to the Ludlowville shale is gradual through a few feet in which the rock becomes lighter colored, slightly arenaceous and more fossiliferous. These passage beds are succeeded by a hard calcareous stratum containing corals, large brachiopods and many other forms. This stratum is continuous for many miles in central New York producing falls or cascades in numerous ravines. It partakes of the general character of the entire group in becoming more arenaceous toward the east and calcareous toward the west.

It was described by Clarke in the Report of the New York State Geologist for 1884, pages 12 and 13, as it appears at Centerfield in Ontario county, under the name Basal limestones.

Lincoln refers to it under the same name in "Geology of Seneca County" [Report of the New York State Geologist, 1894, p. 93]. It is the "Centerfield limestone" at the base of the Canandaigua (Ludlowville) shales described in New York State Museum bulletin 63, 1904. It is well exposed on these quadrangles at the top of the falls in Big Hollow creek, at the top of the falls in the ravine 3 miles east of Romulus, along a small stream 1½ miles south of Fayette, in Kendig creek at MacDougall, along Reeder creek and at Dey landing, also on the west side of the lake at the top of the falls of Wilson's creek, near the west line of the quadrangle.

The succeeding middle beds are generally soft, gray sandy shale with concretions, calcareous lentils and thin sandy flags, in all of which fossils are common but rather less abundant than in the lower and upper parts of the formation. The upper part is mostly soft gray argillaceous shale, though bands of coarser sediment occur near the top in which fossils are very abundant and the rock quite calcareous.

The entire formation shows the increase of arenaceous matter toward the east, bands of sandstone in the horizon of the Ludlowville shales producing escarpments on the sides of Onondaga valley, and at Hamilton in Madison county, affording a fair quality of building stone.

The upper limit of this formation is distinctly marked by the Tichenor limestone that from Onondaga county to Lake Erie is the succeeding formation and produces a large number of cascades or falls below the top of which the Ludlowville shales are exposed.

The best exposures of these beds on these quadrangles may be found below the falls in Bloomer and Fall creeks, 2 miles east of Hayt Corners; along Kendaia creek, on the shores of Seneca lake between Dey landing and the mouth of Indian creek and on Indian creek at the forks. It is finely displayed in the cliffs along the lake shore from a mile north of Dresden for 4 miles; also in the lower part of the Kashong creek ravine to the top of the middle falls. In New York State Museum bulletin 63, accompanying the stratigraphic and paleontologic map of the Canandaigua-Naples quadrangles the following species are listed as having been found in the basal limestones and succeeding Canandaigua (Ludlowville) shales and which are the essential components of the Hamilton fauna in this region:

Worms
Arabellites
Oenonites
Eunicites
Spirorbis angulatus *Hall*
Cornulites tribulis *Hall*
C. mitella *Hall*
Crustaceans
Phacops rana *Green*
Dalmanites boothi (*Green*)
D. boothi *var.* calliteles (*Green*)
Proetus rowi (*Green*)
P. macrocephalus *Hall*
Cyphaspis ornata *Hall*
C. ornata *var.* baccata *Hall & Clarke*
C. craspedota *Hall & Clarke*
Turrilepas devonica *Clarke*
T. squama *Hall & Clarke*
T. nitidula *Hall & Clarke*
T. foliata *Hall & Clarke*
T. tenera *Hall & Clarke*
Schizodiscus capsa *Clarke*
Ostrocodes
Estheria pulex *Clarke*
Pteropods
Styliolina fissurella (*Hall*)
Hyolithus aclis *Hall*
Cephalopods
Orthoceras exile *Hall*
O. nuntium *Hall*
O. crotalum *Hall*
Nautilus liratus *Hall*
Tornoceras uniangulare (*Conrad*)
Bactrites tenuicinctus (*Hall*)
Gastropods
Bellerophon leda *Hall*
B. lyra *Hall*
B. acutilira *Hall*
Platyceras symmetricum *Hall*
P. erectum *Hall*
P. conicum *Hall*
P. attenuatum *Hall*
P. thetis *Hall*
P. bucculentum *Hall*
P. carinatum *Hall*
P. echinatum *Hall*
P. subspinosum *Hall*
Pleurotomaria capillaria *Conrad*
P. itys *Conrad*
P. trilix *Hall*
P. disjuncta *Hall*
P. lucina *Hall*
Loxonema delphicola *Hall*
L. hamiltoniae *Hall*

Diaphorostoma lineatum (*Conrad*)
Cyclonema hamiltoniae *Hall*
C. multilira *Hall*
Straparollus rudis *Hall*
Murchisonia micula *Hall*
Macrochilus hebe *Hall*

Lamellibranchs

Mytilarca oviformis (*Conrad*)
Macrodon hamiltoniae *Hall*
Microdon bellistriatus *Conrad*
Buchiola halli *Clarke*
Cypricardinia indenta (*Conrad*)
Modiella pygmaea *Hall*
Conocardium crassifrons *Conrad*
Grammysia arcuata (*Conrad*)
Goniophora acuta (*Hall*)
Modiomorpha mytiloides *Hall*
M. concentrica (*Conrad*)
M. macilenta *Hall*
Nuculites oblongatus *Conrad*
Actinopteria decussata *Hall*
Aviculopecten princeps (*Conrad*)
Palaeoneilo constricta (*Conrad*)
P. emarginata (*Conrad*)
P. fecunda *Hall*
P. plana *Hall*
P. tenuistriata *Hall*

Brachiopods

Lingula leana *Hall*
L. densa *Hall*
Crania crenistria *Hall*
Craniella hamiltoniae *Hall*
Rhipidomella penelope *Hall*
R. vanuxemi *Hall*
Orthothetes arctostriatus *Hall*
O. pandora (*Billings*)
Stropheodonta concava *Hall*
S. demissa (*Conrad*)
S. (Douvillina) inequistriata (*Conrad*)
S. junia *Hall*
Pholidostrophia nacrea *Hall*
Leptostrophia perplana (*Conrad*)
Chonetes carinatus *Conrad*
C. lepidus *Hall*
C. deflectus *Hall*
C. scitulus *Hall*
Productella navicella *Hall*
P. spinulicosta *Hall*
P. tullia *Hall*
Spirifer angustus *Hall*
S. divaricatus *Hall*
S. fimbriatus (*Conrad*)
S. audaculus (*Conrad*)
S. mucronatus (*Conrad*)
S. consobrinus *d'Orbigny*
S. marcyi *Hall*
S. granulosus (*Conrad*)
Ambocoelia umbonata *Conrad*
A. praeumbona *Hall*
Cyrtina hamiltonensis *Hall*
Nucleospira concinna *Hall*
Parazyga hirsuta *Hall*
Cyclorhina nobilis *Hall*
Trigeria lepida *Hall*
Meristella haskinsi *Hall*
Athyris spiriferoides (*Eaton*)
Atrypa reticularis (*Linné*)
Camarotoechia dotis *Hall*
C. horsfordi *Hall*
C. prolifica *Hall*
C. sappho *Hall*
C. congregata (*Conrad*)
Liorhynchus multicosta *Hall*
L. quadricostatum (*Vanuxem*)
Pentamerella pavilionensis *Hall*
Cryptonella rectirostris *Hall*
C. planirostris *Hall*
Eunella lincklaeni *Hall*
Tropidoleptus carinatus (*Conrad*)

Crinoids

Platycrinus eboraceus *Hall*
Megistocrinus ontario *Hall*
Nucleocrinus lucina *Hall*
Dolatocrinus glyptus *Hall*
D. liratus *Hall*

The following corals were found in the basal limestones:

Zaphrentis halli *Edwards & Haime*
Z. simplex *Hall*
Cystiphyllum varians *Hall*
C. conifolle *Hall*
C. americanum *Edwards & Haime*
Cyathophyllum robustum *Hall*
C. nanum *Hall*
C. conatum *Hall*

Amplexus hamiltoniae *Hall*
Heliophyllum halli *Edwards & Haime*
H. irregulare *Hall*
H. reflexum *Hall*
H. obconicum *Hall*
H. confluens *Hall*
Favosites placenta *Rominger*
F. arbusculus *Hall*
F. argus *Hall*
Alveolites goldfussi *Billings*
Pleurodictyum stylopora *Eaton*
Striatopora limbata *Eaton*

Tichenor limestone

The thin, but widely extended stratum of limestone that separates the Ludlowville from the Moscow shale was first described in the Third Annual report of the Fourth Geological District for 1838, page 298, by Professor Hall as it appears in Seneca county. In that report it is considered as "the terminating rock of the shale last described" (Ludlowville) under the designation Encrinal limestone from the abundance of fragments of crinoidal columns it contains.

In the final report on the fourth district, page 187, it is described as one of the divisions of the Hamilton group. The term "Tichenor" was substituted for "Encrinal" in the title of this formation in *Classification of New York Series of Geological Formations* by Clarke and Schuchert, 1900, from its well known favorable exposure at Tichenor point, Canandaigua lake.

This formation is a thin stratum of calcareous sediment that varies in character from a light colored compact blue limestone a few inches thick to a mass of hard calcareous shale with a thin uneven limestone at the base and other thin lentils of similar character interstratified in the succeeding 4 to 6 feet of shale.

The compact layer has a subcrystalline appearance when broken, due to the fragmentary crinoidal columns, and the surface is at some localities marked by an abundance of Spirifer granulosus, conspicuous for its great size. Otherwise this stratum is not usually very fossiliferous, but the overlying shales are rich in fine specimens of forms common in the shale above and below. Among the fossils found in the Tichenor limestone are:

Phacops rana *Green*
Orthoceras coelamen *Hall*
O. exile *Hall*
Lyriopecten orbiculatus *Hall*
Spirifer granulosus (*Conrad*)
S. mucronatus (*Conrad*)

The more favorable exposures of the Tichenor limestone on these quadrangles may be found at the top of the lower falls in the ravines of Bloomer falls and other creeks 2 miles east of Hayt

Corners; at the forks of Indian creek a mile north of Willard and on the west side of Seneca lake in a small ravine 1½ miles north of Dresden 6 rods above the New York Central Railroad and at the crest of the middle falls in the ravine of Kashong creek.

Moscow shale

This term was applied by Hall in the Third Annual Report of the Fourth District, page 298, to the shales that succeed the Tichenor limestone and are terminated above by the Tully limestone. Following a description of this, the upper division of the Hamilton group, as it appears in Seneca county along the shores of Seneca and Cayuga lakes, he says: "This shale is so well developed, and contains the fossils, particularly the trilobites, in such great perfection, at Moscow, Livingston co., that I have given it that name. . ."

As developed on these quadrangles the formation may be described as a soft mass of gray calcareous shale, very fossiliferous and light colored in the lower beds, the upper being darker, more argillaceous and containing fewer and smaller fossils. As a whole the formation generally assumes the character of the lower beds in a westerly direction and of the upper beds toward the east. At Moscow the dark upper beds are but 11 feet thick while on these quadrangles they constitute about one third the thickness of the formation and in Onondaga and Madison counties, they occupy all of the space but a few feet at the bottom, between the horizon of Tichenor and the Tully limestone.

Concretionary calcareous layers, some of which are continuous for a considerable distance, while others extend but a few feet, composed of an agglomeration of fossils are of frequent occurrence in the lower beds and to a much less degree in the upper, and irregularly formed concretions, also containing many fossils, are common throughout the entire formation.

The list of fossils that compose the fauna of the Moscow shales in the Canandaigua lake section published in Museum bulletin 63, contains 6 worms, 18 crustaceans, 7 cephalopods, 3 pteropods, 21 gastropods, 34 lamellibranchs, 52 brachiopods, 18 bryozoans, 5 corals and 26 crinoids, a total of 190 species.

Exposures in which the entire section of the Moscow shales are accessible may be found in several ravines 1 to 2 miles east of Hayt Corners. The lower part is displayed along Indian creek and its eastern branches and the upper part in Simpson creek in the State Hospital grounds at Willard below the Tully limestone at the quarry, and in the cliffs at Perry point and the adjacent ravine. They appear in the banks of the Keuka outlet and the floor and sides of Bruce's gully afford an ideal display of the upper shales conveniently situated for the collection of fossils, and the entire section may be seen in the Kashong creek ravine between the top of the middle fall and the Tully limestone at the crest of the upper fall.

Tully limestone

The Tully limestone, so named by Vanuxem in the Third Annual Report of the Third Geological District for 1838, from large exposures and superior development in the town of Tully, Onondaga co., is specially interesting not only on account of its own composition and structure, but also from the fact that it is interstratified 250 feet below the top of a series of soft shales that succeed the Onondaga limestone for a thickness of a thousand feet and in which the Tichenor is the only other continuous limestone. The rock is fine grained blue black rather impure limestone that weathers light bluish gray. It is very compact and hard when fresh, but brittle, breaking easily under the hammer and, after long exposure, inclined to crumble into small angular fragments. This tendency impairs the value of this limestone for building purposes, and its impurity for the production of quicklime for which purposes it was formerly quarried to a considerable extent. Its chief economic value at present lies in its adaptability as road metal and in the manufacture of Portland cement.

It is 9 to 15 feet thick on these quadrangles and usually separated into 4 or 5 distinct layers, the lower one 5 to 7 feet thick, the others varying from 1 to 3 feet. Frequent joints divide the strata into massive blocks and these are strewn along the ravines and the lake shore at the foot of the cliffs in which the limestone occurs. The change from the soft dark Moscow shale to the Tully limestone is abrupt, but at the top the overlying Genesee shale is quite calcareous for 3 to 5 feet.

The Tully limestone is an important, easily recognized and reliable stratigraphic datum plane from Chenango county on the east where it is 30 feet thick to Gorham, Ontario co., on the west, where it disappears by thinning out. It is 9 feet thick at the head of the Kashong creek ravine; 12 feet, 6 inches to 13 feet, 6 inches along the Keuka outlet; 14 feet, 6 inches at Miller point; 14 feet at Lodi glen; 13 feet in the quarry at Willard; 11 feet with possibly one or two layers at the top wanting in the old Johnson quarry 1½ miles north of Ovid; and 14 to 15 feet in the ravines east of Hayt Corners.

The lighter color and rugged character of the Tully as compared with the soft dark shales above it, make it a prominent feature in the stratigraphy of the cliffs on the lake shore and in the adjacent ravines. Its line of outcrops on these quadrangles is more than 30 miles long and the frequency and extent of the exposures make it possible to ascertain its position in reference to the lake level with a good degree of accuracy. At the head of the Kashong creek ravine the top of the limestone is 713 feet A. T., with a northward dip that is reversed a little farther south, as it is 560 feet A. T. in a small quarry 1½ miles north of Dresden, and has the same elevation at the Cascade mills in the Keuka outlet gorge. At the mouth of Bruce gully it is 550 feet A. T. rising southward to 600 feet A. T. at the top of the falls in that ravine, and westward to the same elevation at Seneca mills a mile west of Cascade mills. In the Perry point ravine it is 565 feet A. T. Thence southward for 4 miles it is covered by drift to a ravine half a mile north of Plum point where it is 478 feet A. T.

It sinks below lake level 444 feet A. T. on the north side of Plum point, rises 5 feet above in a small arch half a mile farther south, is covered by water for 60 rods, then rises to the hight of 45 feet above the lake in an anticlinal that holds it above the water across Severne point and to the north side of Miller point where with a 2 degree southward dip it finally disappears below the lake level.

Its emergence on the east side is covered by drift, its southern exposure being 50 rods from the lake and 50 feet above it in a small ravine 1 mile south of Lodi Landing. A strong southward dip carries it below the lake level between this ravine and a small gully ¼ mile farther south at the mouth of which the black Genesee shale is exposed. It appears at the mouth of Lodi glen 30 feet above the lake rising continually up the ravine for 75 rods showing a northwestward dip of about 100 feet per mile.

It is prominently displayed in the cliffs and ravines north of Lodi Landing as a slightly undulatory light gray band 40 to 60 feet above the lake level for 3 miles, then sinks to partial submergence ¾ of a mile south of the dock at Willard. It is 150 feet higher in the quarry on Simpson's creek ⅝ mile northeast. Its next outcrop is in the old Johnson quarry 1½ miles north of Ovid at the summit of the ridge that separates the Seneca from the Cayuga lake valley, 840 feet A. T., 395 feet higher than in the depression where it last appears on the lake shore 3½ miles west and but 2 miles farther south.

From this point it descends to 800 feet A. T. in an outcrop near the railroad station at Hayt Corners; 715 feet A. T. in Fall creek; 680 feet A. T. in the next ravine south, and 640 feet A. T. under the bridge over the third ravine, or 160 feet in 1⅜ miles east and ¾ mile south.

At the top of the falls in the Barnum creek ravine it is 680 feet A. T. dipping as everywhere in this immediate vicinity at the rate of 100 to 150 feet per mile toward the southeast. It disappears under Cayuga lake 381 feet A. T. ⅞ of a mile southeast of Little point and 10 miles southeast of its last outcrop on these quadrangles.

Fossils are not generally common in the Tully limestone, but usually may be found in one or more of the layers in considerable numbers at each outcrop.

These are in matter of number species of the fauna below but the presence of the brachiopod Hypothyris cuboides Sowerby (Rhynchonella venustula Hall) gives it definite stamp as a formation which must be regarded the earliest member of the Upper Devonic.

Genesee shale

In the annual and final reports of the fourth geological district, Professor Hall considered the heavy bed of black and dark shales that succeeds the Tully limestone as constituting one formation known at first as the "Upper black shale" to distinguish it from the Lower or Marcellus shale, but later designated "Genesee shale" from its exposure in the Genesee valley. He recognized, however, a marked difference between the upper and lower beds in both lithologic character and the fossils they contain, referring to them frequently as "Upper Genesee" and "Lower Genesee."

On page 422 of the report for 1839 he says: "In this neighborhood, (the Genesee valley in the vicinity of Geneseo) the black shale is succeeded by a thin stratum of limestone." Subsequent investigations under his direction have shown this to be the Genundewa (Styliola) limestone, which is continuous from Ontario county to Lake Erie, interstratified not far from the middle of the beds and that it is the only continuous layer of limestone in that region above the Tichenor limestone.

For these and other reasons more fully set forth in Museum bulletin 63, the use of the term Genesee shale is restricted to beds between the Tully and the Genundewa limestones in Ontario county and westward and, on these quadrangles where the latter does not appear, to a band of calcareous shales and row of fossiliferous concretions in its horizon.

The Genesee shale is a homogeneous mass of densely black thinly laminated bituminous shale that after exposure becomes fissile and splits into flat plates. The beds are usually traversed by approximately parallel series of joints that intersect each other at different angles producing on the surface of horizontal exposures triangles, diamonds, rhomboids and other kindred forms, and in cliffs striking effects like bastions and buttresses. In old exposures the outward angles have been worn away and there are left rounded masses of black shale partly covered in sheltered places by a thin white efflorescence of alum produced by the decomposition of the contained iron pyrites. The formation is 90 feet thick on the Keuka outlet and 75 feet at the east line of the quadrangle.

It is usually exposed more or less favorably wherever the Tully limestone crops out but the following are some of the more accessible localities where it may be seen: in the cliffs and ravine on the south side of the Keuka outlet at Cascade mills; in the lower part of the ravine of Plum creek; along the lake shore and in ravines between Miller point and Starkey point; on the east shore between Faucetts point and Lamoreaux Landing; in all of the ravines in the vicinity of Lodi Landing; in the railroad cut at Willard; in the highway north of Ovid, and in all of the ravines southeast of Hayt Corners.

Fossils are exceedingly rare in the Genesee shale, the densely black portion being practically barren though an occasional lignite and a few conodont teeth are found in them.

The less bituminous shales contain:

Pleurotomaria rugulata *Hall*
Styliolina fissurella *Hall*
Pterochaenia fragilis (*Hall*)
Lingula spatulata *Vanuxem*
Orbiculoidea lodensis (*Vanuxem*)
Liorhynchus quadricostatum (*Vanuxem*)
Probeloceras lutheri *Clarke*
Bactrites aciculum (*Hall*)

Genundewa limestone horizon

In Ontario county and westward to Lake Erie the Genesee shale is succeeded by a band of thin nodular limestones composed principally of myriads of the minute shells of S t y l i o l i n a **f i s s u -**

r e l l a and containing many other species not found below that horizon. This calcareous band formerly known as the Styliola limestone was designated Genundewa limestone in New York State Museum bulletin 63, from its favorable exposure at Genundewa point on Canandaigua lake. · The layers of limestone do not appear on these quadrangles, their most eastern exposure being in a small ravine 2½ miles south of the village of Gorham, Ontario co. but in their place a distinctly marked band of soft gray calcareous and fossiliferous shale is found that has at its base a row of large flattish concretions which in the cliffs south of Big Stream point on Seneca lake and a few other localities form a continuous layer of rather soft concretionary limestone.

The formation emerges from the lake at Starkey point on the west side and Faucetts point on the east and is displayed in the cliffs toward the north with fallen concretions and blocks of the gray shale strewn along the beach beneath. It may be seen in the walls of Lodi glen and other ravines, and is accessible in the Lehigh Valley Railroad cut at Willard. It is covered by drift in the eastern part of the quadrangle.

An anticlinal fold brings the concretionary limestone above the water south of Big Stream point (Glenora) 2½ miles south of these quadrangles. This is the locality referred to by Professor Hall on page 214 of the Report of the Fourth Geological District under an erroneous impression that it was Tully limestone.

This formation was described by Dr D. F. Lincoln on pages 99 and 100 of the Fourteenth Annual Report of the New York State Geologist and correlated as the base of the Portage group. The fossils collected by him from this gray band on Seneca lake were identified by Dr Clarke as follows:

Manticoceras patersoni (*Hall*)
Bactrites *sp.*
Gomphoceras *cf.* manes *Hall*
Paleotrochus praecursor *Clarke*
Pleurotomaria capillaria *Conrad*
Loxonema noe *Clarke*
Loxonema *var.*
Styliolina fissurella *Hall*
Buchiola retrostriata (*v. Buch*)
Palaeoneilo muta *Hall*
Pterochaenia fragilis (*Hall*)
Atrypa reticularis *Linné*
Ambocoelia umbonata *Hall*
Sp. *cf.* subumbona
Chonetes scitulus *Hall*
Liorhynchus mesacostalis *Hall*
L. globuliformis (*Vanuxem*)
Orthothetes *sp.*
Orbiculoidea lodensis (*Vanuxem*)
Orbiculoidea, small form
Lingula spatulata *Vanuxem*
Cladochonus, abundant in the concretions

West River shale

Succeeding the Genundewa limestone horizon there is a heavy bed of dark and black shales referred to in the early reports as the upper beds of the Genesee shale. In Ontario county and westward there is a distinctive difference between the lower dark gray fossiliferous and slightly calcareous shales and the densely black and bituminous shales of the upper part from which they are separated by a few feet of hard blue shales and thin flags. They become more homogeneous toward the east and although the difference is discernible to the careful observer, on the west side of Seneca lake it is not very clearly defined and in the Cayuga lake valley is not recognizable.

For this reason the dark shales that in this quadrangle lie between the Genundewa limestone horizon and the base of the Cashaqua are included in one division as West River shale so named from their abundant exposure in the West River valley in Yates county. The formation is well displayed in the ravine of Plum creek; along the lake shore at Starkey point and the cliffs at the south, near Faucetts point on the east side of the lake and in nearly all of the ravines toward the north to Willard.

Fossils are exceedingly rare in the upper and more bituminous beds and not at all common in the lower, from which the following species have been obtained:

Bactrites aciculum *Hall*
Gephyroceras *sp.*
Pleurotomaria rugulata *Hall*
Buchiola retrostriata (*v. Buch*)
Pterochaenia fragilis (*Hall*)
Panenka *sp.*
Lunulicardium curtum *Hall*
Lingula spatulata *Vanuxem*
Orbiculoidea lodensis (*Vanuxem*)
Liorhynchus quadricostatum (*Vanuxem*)
Melocrinus clarkei *Williams*

Cashaqua shale

This formation, which receives its name from its exposure along Cashaqua creek in Livingston county, is there a bed something more than 100 feet thick of light, soft, rather calcareous shale, succeeding black shales and distinctly limited at the top by shales of a like bituminous character. In the Naples valley it is also distinctly differentiated from the shale below and above it, but is decidedly more arenaceous, containing at two horizons bands of sandstones and frequent flags. There is also interstratified in the upper part a thin stratum of limestone of a peculiar character and known as the Parrish limestone that may be easily traced with the black

Rhinestreet shale, that everywhere in the western part of the State caps the Cashaqua shale, into the Keuka lake valley in the southern part of which the limestone reaches its greatest development so far as it is exposed, but the black band of Rhinestreet shale is reduced in thickness to about 10 feet and the light shales intervening between it and the limestone are also very much diminished.

The Parrish limestone is recognizable in Big Stream ravine with the Rhinestreet shale 10 inches thick overlying it, the intervening shales having thinned entirely out.

The only exposure of their horizon on this quadrangle on the west side of the lake is on Plum creek half a mile above Himrods. Neither limestone nor black shale appears here but a band of calcareous olive shale containing many fossils indicates their place in the strata.

The proportion of sandy sediment in the Cashaqua beds is much greater in the upper part and increases toward the east and south to such an extent that only the lower beds conform strictly to the description of the Cashaqua shale as it appears in Cashaqua creek while the upper contains many flags and thick layers of hard blue gray sandstone some of which split into even flags while others are compact.

Exposures at Starkey and North Hector show that with the incoming of the sandy sediments a gradual change in the fauna appeared, brachiopods which are not found in these beds in the Naples valley or farther west occurring in thin calcareous layers, and masses of the coral Cladochonus about 100 feet above the base of the formation.

From this horizon upward through several hundred feet of shales and sandstones there are irregular alternations and combinations of the Naples and Ithaca faunas and toward the east a gradual segregation of the latter in the formation succeeding the Cashaqua. This formation is well exposed along Plum creek below and above Himrods, in the ravine and along the dugway roads east of Starkey, along the lake shore north of Glenora, and on the east side from the south line of the quadrangle to the north side of North Hector point, and in the ravines of Curry, Breakneck, Lodi, Tommy and Sixteen Falls creeks. The sandstones are exposed in old quarries in the western part of the village of Ovid and in the vicinity of Scott Corners. The Cashaqua shale is not a very fossiliferous formation but thin seams in which fossils are fairly common occur at all horizons.

Bactrites aciculum (Hall), Probeloceras lutheri Clarke, Pterochaenia fragilis (Hall) and Buchiola retrostriata (von Buch) occur in the lower beds and in the shaly layers throughout the formation. A thin calcareous seam in a sandstone 125 feet above the base of the formation exposed by th side of the dugway road ½ mile east of Starkey station contains:

Leptrostrophia mucronata (*Conrad*)
Spirifer mucronatus *Conrad var.* posterus *Hall & Clarke*
Sp. laevis *Hall*
Cladochonus
Crinoid stems

The higher sandstones on Breackneck creek at North Hector and on Lodi creek contain in addition:

Ambocoelia umbonata *Hall*
Cyrtina *sp.*
Productella spinulicosta *Hall*
Chonetes lepidus *Hall*
Honeoyea major *Clarke*

and Liorhynchus quadricostatum Hall occurs in the sandstones at Ovid and several other species of brachiopods in the quarries in this horizon near the east line of the quadrangle.

Rhinestreet shale

In the region about the south end of Seneca lake and westward to Lake Erie this shale succeeds the Cashaqua shale with a thickness of 165 feet. It is represented on this quadrangle by 2 feet of black shale, in the ravine of Plum creek half a mile west of Himrods. It appears at the Big Stream ravine at Glenora, but is not recognized on the east side of the lake on these quadrangles. It is a well defined feature in the stratigraphy of western New York and is more fully described in Museum bulletins 63, 81 and 101.

Hatch shale and flags

This formation is the stratigraphic equivalent of the lower Gardeau beds in the Genesee river section and consists of a series of shales and sandstones aggregating about 350 feet in thickness.

The shales range from black to light blue and from hard sandy or slaty to soft and blocky, and there are frequent layers of hard blue sandstone from 2 inches to 2 feet in thickness occurring at irregular intervals, some of which are continuous for long distances without change of character or thickness, while others thin out or become shaly and disappear in a few rods. The lower beds of this formation are much softer than the upper Cashaqua beds and in some parts bear a close resemblance to the olive and blue shales of the lower beds of that formation.

The increase in the proportion of sand in the sedimentation toward the east so noticeable in the upper beds of the Cashaqua is also apparent in this formation though to a less degree.

The gradual change in the character of the fauna in that direction is, however, still more marked.

In the Genesee river section no fossils but those of the normal Portage or Naples fauna are found in these beds. At Naples near the top a thin seam shows remains of brachiopods broken and crushed beyond recognition but they do not occur below that horizon, while in this region vertical sections show frequent alterations of the normal Naples fauna and the brachiopodous Ithaca fauna of central New York; indication of oscillation between them in which the latter acquires predominance in the Cayuga lake valley but not to the exclusion of the former.

Although this formation covers a large area on this quadrangle there are few satisfactory exposures and none that are favorable for an exhaustive collection of its fossils.

The following species have been obtained from the Hatch shale and flags in the Seneca lake valley, mainly from the region south of this quadrangle:

Manticoceras patersoni (*Hall*)
Probeloceras lutheri *Clarke*
Tornoceras uniangulare (*Conrad*)
Orthoceras bebryx *Hall*
Bactrites
Styliolina fissurella *Hall*
Bellerophon koeneni *Clarke*
Loxonema noe *Clarke*
Spirifer laevis *Hall*
Sp. mucronatus *var.* posterus *Hall & Clarke*
Sp. subumbona *Hall*
Productella speciosa *Hall*
Schizophoria impressa (*Hall*)
Atrypa reticularis *Linné*
Centronella julia *A. Winchell*
Chonetes scitulus *Hall*
C. lepidus *Hall*
Productella spinulicosta *Hall*
Strophalosia truncata *Hall*
Leptostrophia mucronata (*Vanuxem*)
Buchiola retrostriata (*v. Buch*)
Lingula spatulata *Vanuxem*
Pterochaenia fragilis (*Hall*)
Paracardium doris *Hall*
Lunulicardium ornatum *Hall*
Honeoyea erinacea *Clarke*
Paleoneilo *sp.*
Cladochonus

Grimes sandstone

This is a well defined arenaceous band easily recognized in the region west of these quadrangles as far as the Genesee river. It is made distinctive in the Naples and Dansville valleys by containing the lowest brachiopod faunule in the Portage section of that region.

Data for its location on this map are derived principally from field work on the quadrangles at the south and west of this one, the few exposures here not being sufficient for its positive identification.

Its position is approximately indicated on the map and its assigned thickness is 75 feet.

West Hill (Gardeau) flags and shale

Except that the proportion of sandstones in the shales is somewhat greater and more uniformly distributed there is very little difference between the stratification of this formation and the West Hill beds below. They are, however, less fossiliferous. A few representatives of the Ithaca fauna are found in all parts as are also a small number of species common in the Naples fauna.

Soft gray shales resembling the Cashaqua shale, exposed on Butcher hill, in the upper part of this formation, contain obscure goniatites, orthoceratites and Cladochonus, but no brachiopods.

High Point sandstone

This formation is important stratigraphically and economically in the Genesee river section. There it contains only fossils of the Portage fauna but is stratigraphically continuous with the High Point sandstones of the Naples section where it contains mainly brachiopods common in the Chemung fauna. It becomes shaly in some parts toward the east but can be traced at least as far as the region south of these quadrangles. There are here but small isolated exposures of its horizon in small ravines on the higher slopes of Butcher hill.

Prattsburg sandstone-Wiscoy shale
Chemung sandstone

The position of these formations at the crest of the high ridge between the Seneca lake and Cayuga lake valleys where there are no favorable exposures is indicated from data obtained on the Watkins quadrangle. For description of these higher beds and lists of fossils contained in them see Museum bulletins 63, 81 and 101.

DIP

The average dip of the rock strata on these quadrangles is approximately 24 feet per mile toward the south and toward the west, the latter dip being caused mainly by the decrease in that direction of the thickness of nearly all of the formations represented on the map. The amount of dip between different points is greatly affected, however, by the presence of a series of undulations or low anticlinal folds that render it exceedingly variable and in many cases reverse it.

The color line on the map that indicates the position of the Tully limestone shows the irregularity of the dip in the direction of the shores of the lake and the larger undulation of the strata, to which attention has been directed in the description of that formation.

Variations in the western dip are less noticeable to the casual observer on account of their less favorable exposure in rugged and sinuous ravines away from the level lake which on the shore makes the smallest variation from the normal southern dip easily discernible.

Most of the larger ravines on both sides of the valley show a dip toward the lake, indicating that the location of the depression now partly occupied by the waters of Seneca lake was primarily determined by a synclinal fold of the rock strata extending in the same general direction as the present valley that was very greatly enlarged and deepened by subsequent erosion.

At the following localities on the west side of the lake an eastward dip is seen, at the falls of Wilson creek near the west line of the quadrangle and 3½ miles south of Geneva it is 100 to 150 feet per mile; on Kashong creek the Tully limestone at the top of the falls dips toward the northeast at the rate of more than 100 feet per mile. On the Keuka outlet a sharp fold in the Tully limestone extending from northeast to southwest, has produced what is almost equivalent to a fault.

The Tully limestone appears in the top of a conical hill 1¼ miles southwest from Dresden at 565 A. T. and again at about the same level at the mouth of Bruce gully. It is exposed along up the south side of the gorge to the Cascade mills where it produces a cascade. The bottom and sides of the gorge are covered for nearly a mile west to Seneca mills where the Tully reappears at the top of a second cascade 40 feet higher than at the Cascade mills. This curious phenomenon of a stream of water flowing over the same stratum of rock at two different levels is duplicated in the Great gully ravine 2½ miles south of Union Springs, where a hard band of calcareous shale produces three cascades in a similar manner. The situation is very similar except that but one fall occurs in the Bruce gully where the limestone is exposed in the bank 10 rods from the mouth at 550 A. T. It is covered for some distance up the ravine but occasional outcrops of the Moscow shale show that it is nearly level to about 25 rods from the mouth above which the strata rise rapidly toward the south and west for 35 rods and then are nearly level for 15 rods to the falls where the limestone crosses the ravine at 595 A. T. or 45 feet higher than at the mouth.

An exposure of Hamilton shale on the south side of Keuka outlet half a mile above Dresden shows a strong dip toward the lake.

Exposures in the south side of Perry point show a northeast dip and the top of the Tully limestone is 120 feet higher in the Perry point ravine than at a point directly east on the opposite side of the lake.

The apex of a fold crosses diagonally the ravine of Plum creek ¾ mile from the lake. On the east side of the fold the strata descend toward the east at the rate of 150 feet or more per mile. On the west side there is a slight western dip for about half a mile when it is again reversed and is quite strong toward the lake. At the Severn arch the top of the Tully is 45 feet above the lake level but on the opposite side it is below it, showing an eastward dip of 20 feet or more per mile.

At the south end of the lake the strata on the east side are about 25 feet lower than on the west. Exposures are not favorable to the measurement of dip on the east side in the southern part of the quadrangle, but in the Lodi glen the Tully limestone shows a western dip of 150 feet per mile, and the other ravines in this vicinity show that this steep dip toward the lake continues for at least 8 miles and that some of the apparent undulations of the limestones are caused by sinuosities in the line of outcrop. A western dip of more than 200 feet per mile is noticeable in the quarries and roadside exposures in the western part of the village of Ovid.

On the east side of the ridge the eastward dip toward Cayuga lake is shown in the ravines east of Hayt Corners and in the Big Hollow creek and other ravines farther north. On the opposite side of the lake conditions are much like those on Seneca lake, the western dip being increased to many times the average.

The diagram accompanying the map is designed to show highly exaggerated the variations in the dip along the east and west line of 42° 40′ across the Ovid and Genoa quadrangles, a distance of 26 miles.

Glacial striae may be seen on the exposed surface of the Tully limestone at many places and also on the higher sandstones. Much of the flagging about the village of North Hector is finely striated and a most remarkable display of groovings and striations may be seen on the surface of the flag walk 80 feet long by 6 feet wide in front of the hotel at North Hector point.

The flags are from the upper Cashaqua beds and are the surface layers in a quarry a mile north of North Hector.

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New York State Education Department

New York State Museum

JOHN M. CLARKE, Director

PUBLICATIONS

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Museum annual reports 1847–date. *All in print to* 1894, 50c *a volume,* 75c *in cloth;* 1894*-date, sold in sets only;* 75c *each for octavo volumes; price of quarto volumes on application.*

These reports are made up of the reports of the Director, Geologist, Paleontologist, Botanist and Entomologist, and museum bulletins and memoirs, issued as advance sections of the reports.

Director's annual reports 1904–date.

1904. 138p. 20c.
1905. 102p. 23pl. 30c.
1906. 186p. 41pl. 35c.
1907. 212p. 63pl. 50c.

These reports cover the reports of the State Geologist and of the State Paleontologist. Bound also with the museum reports of which they form a part.

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, O; 2, 14–16, Q.

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

The annual reports of the original Natural History Survey, 1837–41, are out of print.

Reports 1–4, 1881–84, were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum report. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

Separate volumes of the following only are available.

Report	*Price*	*Report*	*Price*	*Report*	*Price*
12 (1892)	$.50	17	$.75	21	$.40
14	.75	18	.75	22	.40
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Paleontologist's annual reports 1899–date.

See first note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Those for 1901–3 were issued as bulletins. In 1904 combined with the Director's report.

Entomologist's annual reports on the injurious and other insects of the State of New York 1882–date.

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Report	*Price*	*Report*	*Price*	*Report*	*Price*
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5	.25	12	.25	20 (" 97)	.40
6	.15	13	*Free*	21 (" 104)	.25
7	.20	14 (Bul. 23)	.20	22 (" 110)	.25
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9	.25	16 (" 36)	.25		

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Botanist's annual reports 1867–date.

Bound also with museum reports 21–date of which they form a part; the first Botanist's report appeared in the 21st museum report and is numbered 21. Reports 21–24, 29, 31–41 were not published separately.

Separate reports for 1871–74, 1876, 1888–98 are out of print. Report for 1899 may be had for 20c; 1900 for 50c. Since 1901 these reports have been issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have also been published in volumes 1 and 3 of the 48th (1894) museum report and in volume 1 of the 49th (1895), 51st (1897), 52d (1898), 54th (1900), 55th (1901), 56th (1902), 57th (1903), 58th (1904), 59th (1905) and 60th (1906) reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum memoir 4.

Museum bulletins 1887–date. O. *To advance subscribers*, $2 *a year or* $1 *a year for division* (1) *geology, economic geology, paleontology, mineralogy*; 50c *each for divisions* (2) *general zoology, archeology and miscellaneous*, (3) *botany*, (4) *entomology*.

Bulletins are grouped in the list on the following pages according to divisions.

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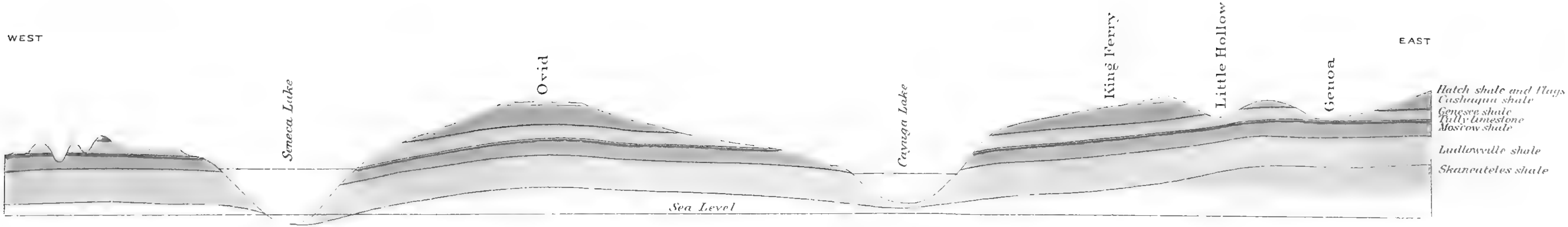

EAST-WEST SECTION ON OVID AND GENOA QUADRANGLES AT LINE OF 42° 40′ N
SHOWING THE LOW SYNCLINES OF THE LAKE BASINS

VERTICLE SCALE 1 INCH = 1000 FEET
HORIZONTAL " 1 " = 2 MILES

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LAKE
CAYUGA LAKE
GENEVA
OVID
LODI
ROMULUS
VARICK
FAYETTE
WATERLOO
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